Signals and Circuits

ENGR 35500

Digital system

https://www.nutsvolts.com/magazine/article/April2016_Beginner-Guide-to-Digital-Electronics

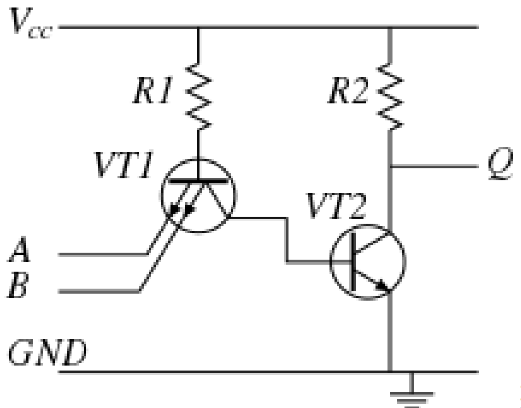
KENT STATE UNIVERSITY

Digital Electronics

- The main characteristic of digital system is their ability to represent and manipulate discrete element of information.
- Digital Electronics represents information (0, 1) with only two discrete values.
- Ideally

  "no voltage" (e.g., 0v) represents a 0 and
  "full source voltage" (e.g., 5v) represents a 1
- Realistically

  "low voltage" (e.g., <1v) represents a 0 and
  "high voltage" (e.g., >4v) represents a 1
- We achieve these discrete values by using switches.
- We use transistor switches, which operates at high speed, electronically, a small in size.
- Digital electronic circuits are usually made from large assemblies of logic gates.



Digital Electronics

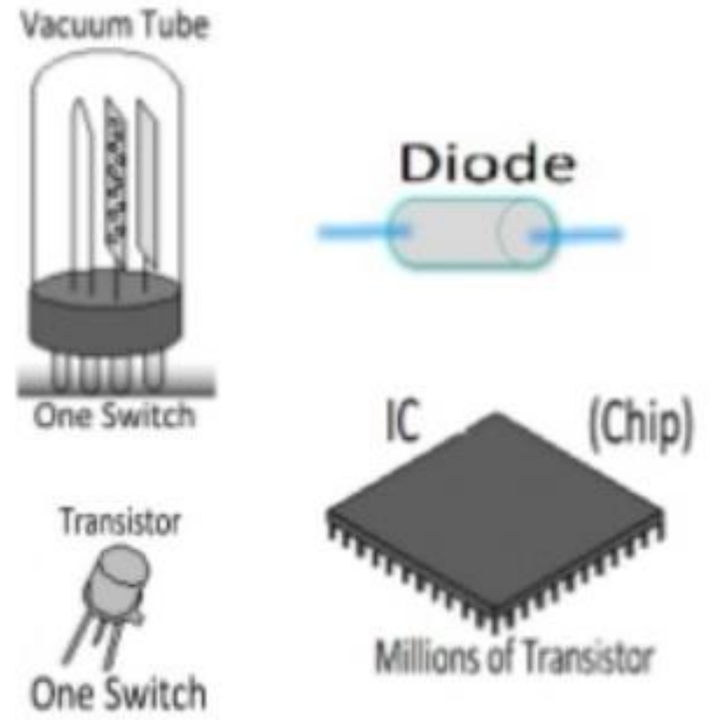
- Digital Electronics Quick History

✓Prior to digital technology, electronic transmission was limited to analog technology, which conveys data as electronic signals of varying frequency or amplitude.

✓In the 1930's the prototypes of the computer were constructed from mechanical switches (vacuum tubes) and relays. These were comparatively slow, large, and produced a great deal of heat.

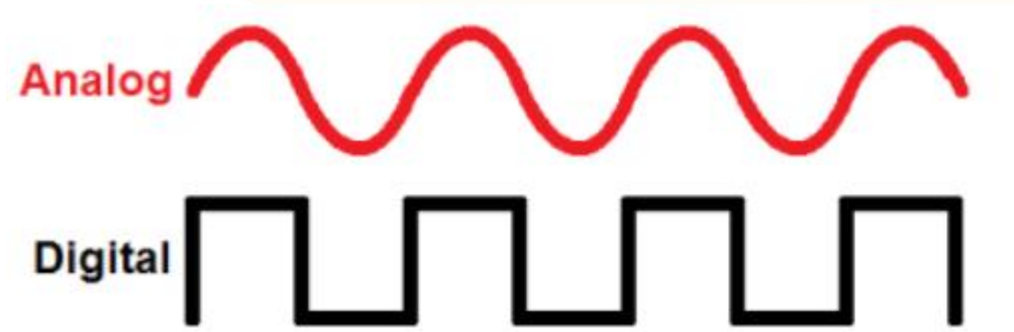
✓The next stage in the 1940's was the use of electronic diodes, and while these were better but they were unreliable.

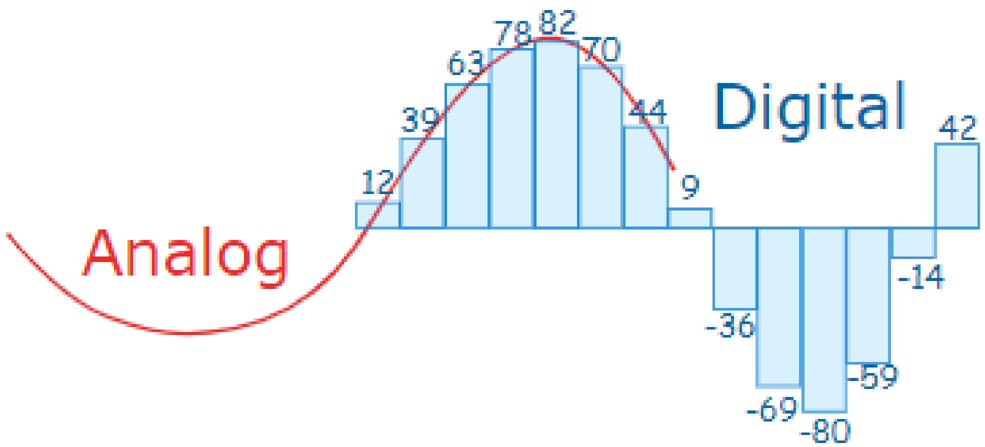
✓The next stage was the result of the development in 1947 of the transistor which was much smaller, faster and cooler. Simple transistors were replaced by integrated circuits (ICs) and that got smaller and smaller and finally deposited on silicon to be put into a "chip".



Analog versus Digital

- **Analog** systems process time-varying signals that can take on any value across a continuous range of voltages (in electrical/electronics systems).
- **Digital** systems process time-varying signals that can take on only one of two discrete values of voltages (in electrical/electronics systems).
  - Discrete values are called 1 and 0 (ON and OFF, HIGH and LOW, TRUE and FALSE, etc.)

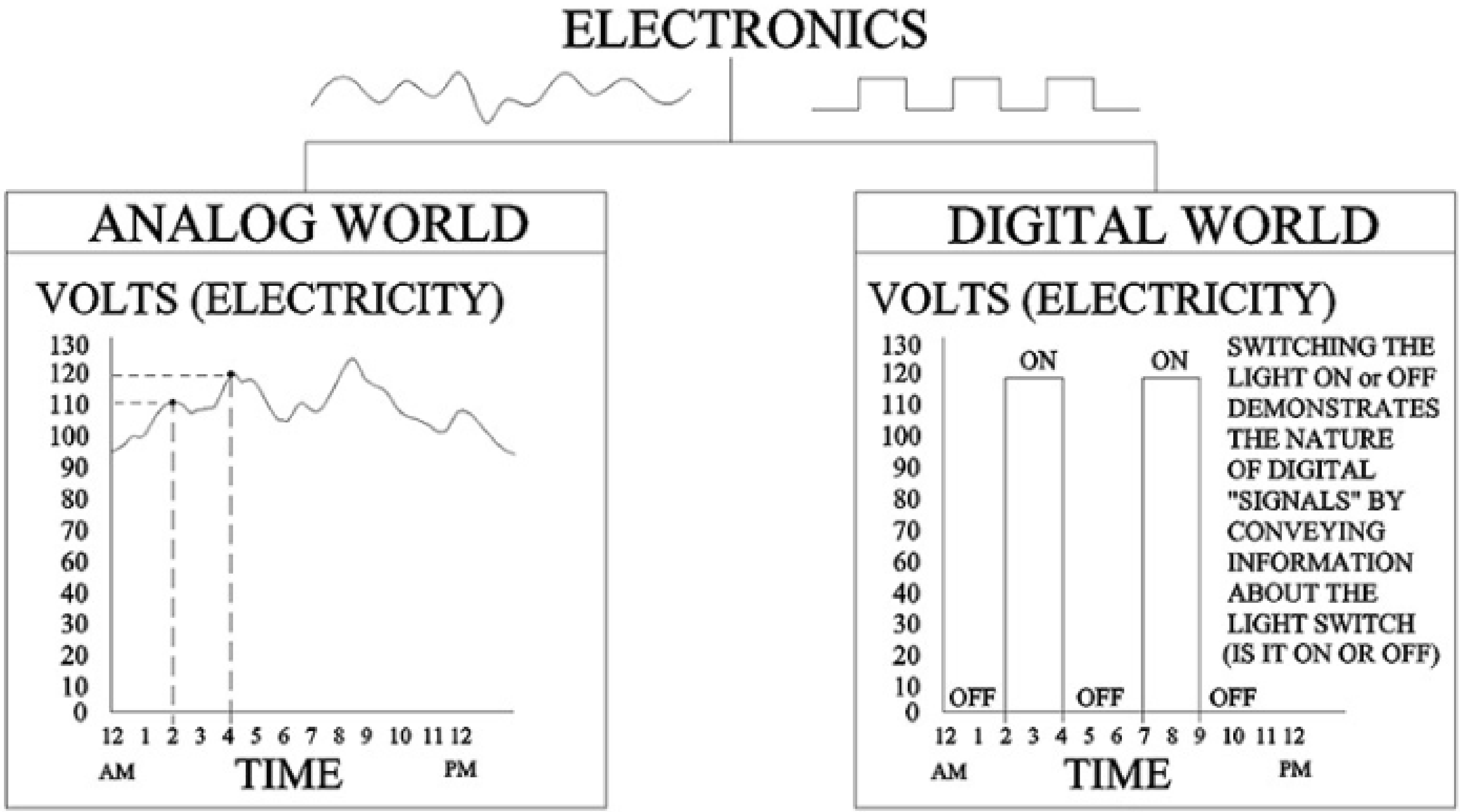




Example:
An analog clock, whose hands move smoothly and continuously.
A digital clock, whose digits jump from one value to the next.

KENT STATE UNIVERSITY

Analog versus Digital



KENT STATE UNIVERSITY

Digital information

- Two lights to show information

PORCH LIGHT #2	BEDROOM LIGHT #1	MESSAGE
OFF	OFF	PARENTS STILL HOME
OFF	ON	STOP OVER
ON	OFF	MEET AT PIZZA SHOP
ON	ON	MEET AT SUE'S HOUSE

- Four lights to show more information

	GARAGE LIGHT #4	LIVINGROOM LIGHT #3	PORCH LIGHT #2	BEDROOM LIGHT #1	MESSAGE
0	0	0	0	0	PARENTS STILL HOME
1	0	0	0	1	STOP OVER
2	0	0	1	0	MEET AT PIZZA SHOP
3	0	0	1	1	MEET AT SUE'S HOUSE
4	0	1	0	0	MEET AT JANE'S HOUSE
5	0	1	0	1	MEET AT JOE'S HOUSE
6	0	1	1	0	MEET AT BOB'S HOUSE
7	0	1	1	1	ETC.
8	1	0	0	0	
9	1	0	0	1	
10	1	0	1	0	
11	1	0	1	1	
12	1	1	0	0	
13	1	1	0	1	
14	1	1	1	0	
15	1	1	1	1	

KENT STATE UNIVERSITY

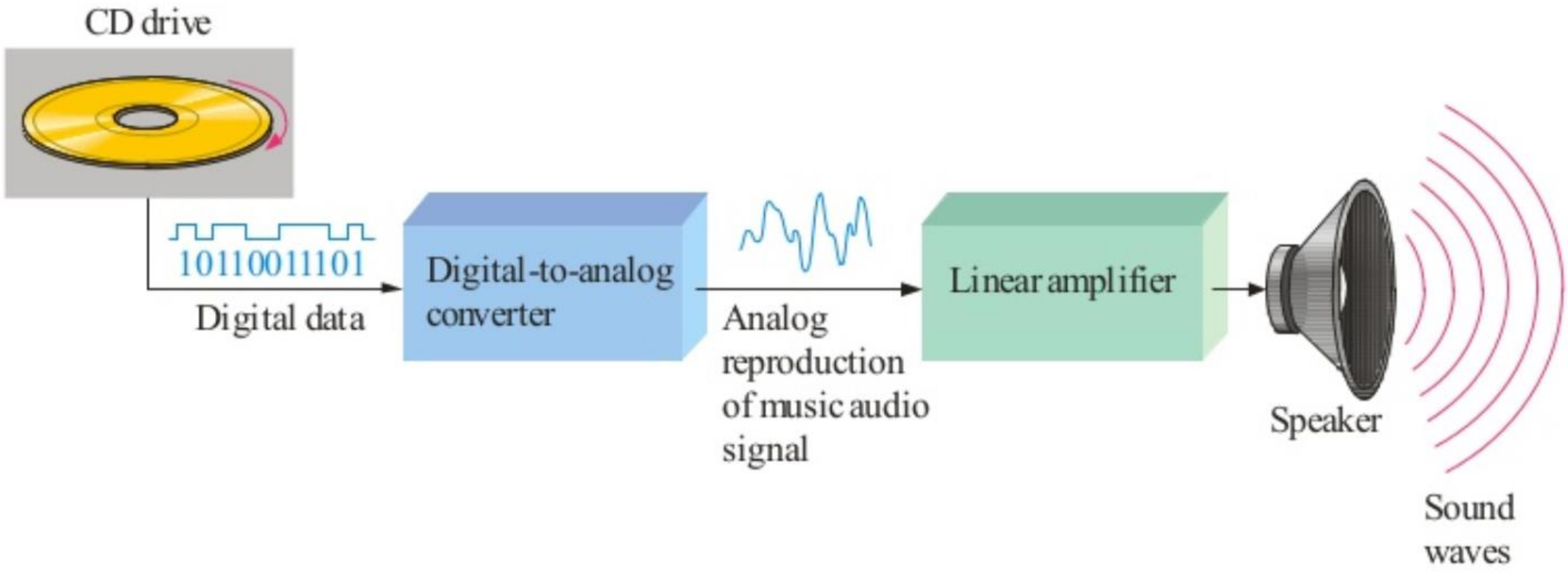
Analog versus Digital

	Advantages	Disadvantages
Digital system	1.Less expensive 2. More reliable 3. Easy to manipulate 4. Flexible 5. Compatibility with other digital system 6. Integrated networks 7. Easy storage	1. Sampling Error 2. Digital communications require greater bandwidth 3. The detection of digital signals requires the communications system to be synchronized
Analog system	1. Uses less bandwidth 2. More accurate	1.High cost of signal conversion inside the display 2.Upgrade to digital interface not possible

KENT STATE UNIVERSITY

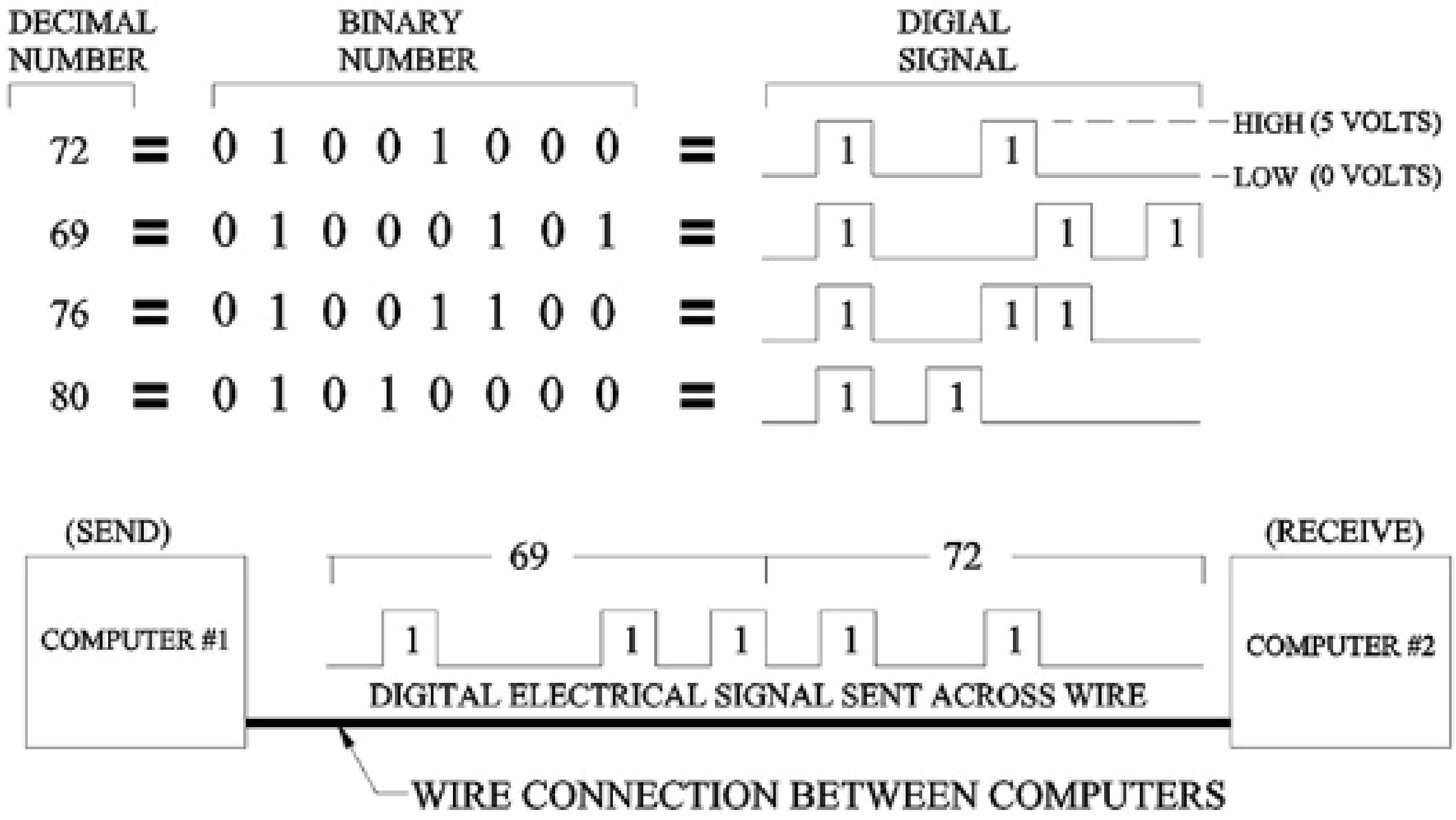
Analog and Digital Systems

- Many systems use a mix of analog and digital electronics to take advantage of each technology.
- Example: A typical CD player accepts digital data from the CD drive and converts it to an analog signal for amplification.



KENT STATE UNIVERSITY

Communication for digital systems



Numbering system

- Many numbering systems are in use in digital technology.

- The most common are the:

Decimal 537_{10}
Binary 101001_{2}
Octal 148_{8}
Hexadecimal $4BAF_{16}$

- To avoid confusion while using different numeral systems, the base of each individual number may be as specified by writing it as a subscript of the number.

Numbering system

To decimal

$$number_b = [d_N \ldots d_2 d_1 d_0]_b = \sum_{n=0}^{N} d_n b^n = d_0 b^0 + d_1 b^1 + d_2 b^2 + \ldots + d_N b^N$$

b - numeral system base

d_n - the n-th digit

n - can start from negative number if the number has a fraction part.

$N+1$ - the number of digits

Examples:

$$2538_{10} = 2\times10^3+5\times10^2+3\times10^1+8\times10^0$$

$$10101_2 = 10101\text{B} = 1\times2^4+0\times2^3+1\times2^2+0\times2^1+1\times2^0 = 16+4+1= 21$$

$$27_8 = 2\times8^1+7\times8^0 = 16+7 = 23$$

$$28_{16} = 28\text{H} = 2\times16^1+8\times16^0 = 40$$

$$(1101.0111)_2 = (1\times2^3) + (1\times2^2) + (0\times2^1) + (1\times2^0) + (0\times2^{-1}) + (1\times2^{-2}) + (1\times2^{-3}) + (1\times2^{-4})$$

$$= 8 + 4 + 0 + 1 + 0 + 0.25 + 0.125 + 0.0625 = 13.4375_{10}$$

KENT STATE UNIVERSITY

Numbering system

Decimal to

Decimal to Binary

Here is an example of using repeated division to convert 1792 decimal to binary:

Decimal Number	Operation	Quotient	Remainder	Binary Result
1792	÷ 2 =	896	0	0
896	÷ 2 =	448	0	00
448	÷ 2 =	224	0	000
224	÷ 2 =	112	0	0000
112	÷ 2 =	56	0	00000
56	÷ 2 =	28	0	000000
28	÷ 2 =	14	0	0000000
14	÷ 2 =	7	0	00000000
7	÷ 2 =	3	1	100000000
3	÷ 2 =	1	1	1100000000
1	÷ 2 =	0	1	11100000000
0	done.			

$$1792_{10} = (11100000000)_2$$

Decimal to Octal

Here is an example of using repeated division to convert 1792 decimal to octal:

Decimal Number	Operation	Quotient	Remainder	Octal Result
1792	÷ 8 =	224	0	0
224	÷ 8 =	28	0	00
28	÷ 8 =	3	4	400
3	÷ 8 =	0	3	3400
0	done.			

$$1792_{10} = (3400)_8$$

Decimal to Hexadecimal

Here is an example of using repeated division to convert 1792 decimal to hexadecimal:

Decimal Number	Operation	Quotient	Remainder	Hexadecimal Result
1792	÷ 16 =	112	0	0
112	÷ 16 =	7	0	00
7	÷ 16 =	0	7	700
0	done.			

$$1792_{10} = (700)_{16}$$

- A repeated division and remainder algorithm can convert decimal to binary, octal, or hexadecimal.

1. Divide the decimal number by the desired target radix (2, 8, or 16).
2. Append the remainder as the next most significant digit.
3. Repeat until the decimal number has reached zero.

$$110_{10} = (?)_2$$

$$110_{10} = (?)_8$$

$$110_{10} = (?)_{16}$$

KENT STATE UNIVERSITY

Numbering system

Decimal to

Decimal to Binary conversion

$(31.6875)_{10} = (?)_2$

For Integer part, the number is divided by 2 and the remainders are read in the direction of arrow from down to top corresponding to MSB and LSB as shown below

2	31	Remainder
2	15	1 LSB
2	7	1
2	3	1
	1	1
		1 MSB

$(31)_{10} = (11111)_2$

For fractional part, the digits are multiplied by two and integer part defines the number as shown below, the numbers are now read from top to bottom as shown by arrow, the multiplication is done ideally till the decimal part or fractional part becomes zero or the repetition starts.

0.6875 x 2 = **1**.3750 1

0.375 x 2 = **0**.7500 0

0.7500 x 2 = **1**.500 1

0.500 x 2 = **1**.000 1

$(0.6875)_{10} = (0.1011)_2$

Complete answer is $(31.6875)_{10} = (11111.1011)_2$

Practice

$$110.34_{10} = (?)_2$$

$$110.11_2 = (?)_{10}$$

https://www.tutorialcup.com/digital-electronics/number-systems.htm